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INCREMENTAL COST TO CANADIANS OF THE PROPOSED HEAVY DUTY ENGINE REGULATIONS TO LIMIT EMISSIONS FROM TRUCKS AND BUSES

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R237/4734R

TABLE OF CONTENTS

PAGE

Sommaire..... iv

Executive Summary..... vii

1.0 Purpose..... 1

2.0 Introduction..... 2

3.0 Cost of Changes in U.S.A..... 6

4.0 Additional Cost to Canadians Assuming No Changes to Canadian Standards..... 8

5.0 Costs to Canadians of Proposed 1989 Regulations..... 14

6.0 Incremental Cost to Canadians of the Proposed Canadian 1989 Regulations..... 27

6.1 Discussion..... 27
6.2 Sample Calculation for Diesel Fuel Costs..... 27

7.0 The Incremental Cost to Canadian of Proposed 1995 Regulations..... 30

8.0 Sample Calculation For Cost of Gasoline..... 48

9.0 Cost of Replacing Particulate Traps..... 50

10.0 Cost to Canadians of Proposed 1989 Regulations for Gasoline Engines..... 55

11.0 Cost to Canadians of Proposed 1989 Regulations and 1995 Regulations for Gasoline Engines..... 61

12.0 Cost of Alternate Fuels in Buses..... 65

13.0 Present Value Calculations..... 68

PAGE

LIST OF TABLES AND CHARTS

Table 1: HDDV Fuel Economy, Average Annual Distance..... 11

Table 2: Forcast of Sales of Trucks With Diesel Engines..... 11

Table 3: Estimated Cost to Canadians of No change..... 12

Table 4: Cost of 1989 Regulations..... 22

Table 5: Incremental Cost of 1989 Regulations..... 26

Table 6: Increment Cost of Engines Tuned to U.S. 1988 Regulations..... 29

Table 7 Forecast of Sales of Trucks Assuming 1995 Regulations. 32

Table 8: Cost of 1995 Regulations Light Trucks..... 43

Table 9: Cost of 1995 Regulations Medium Trucks..... 44

Table 10: Cost of 1995 Regulations Medium Heavy Trucks..... 45

Table 11: Cost of 1995 Regulations Heavy Trucks..... 46

Table 12: Incremental Cost of 1995 Regulations..... 47

Table 13: Incremental Cost of Replacing Traps with Mufflers..... 53

Table 14: Incremental Cost of 1995 Regulations with Tampered Traps..... 54

Table 15: Forecast of Sales of Trucks with Gasoline Engines..... 57

Table 16: Cost of 1989 Regulations for Gasoline Powered Trucks.. 60

Table 17: Forecast of Sales of Trucks With Gasoline Engines Assuming Adoption of 1995 Regulations..... 62

Table 18: Cost of 1988 and 1995 Regulations for Gasoline Powered Trucks..... 63

PAGE

LIST OF TABLES AND CHARTS

Table 19: Incremental Cost of Impact of 1995 Regulations on Trucks with Gasoline Engines..... 64

Table 20: Expected Cost to Meet 1995 Regulations for Each New Bus Purchased..... 67

Table 21: Expected Present Value (1986) of Incremental Allocative Cost of Canadian 1989 and Canadian 1995 Regulations..... 69

Figure 1: Transient Test NOx/PART..... 18

Figure 2: Trade-Off Between Nox, HC, Particulates, BSFC..... 19

Figure 3: Influence of Cetane Number on BSNOx - BSFC..... 20

Figure 4: Particulate, NOx, and Hydrocarbon Emissions..... 37

SOMMAIRE

Les camions utilisant l'essence comme carburant

Cette analyse se rapporte aux deux possibilités réglementaires suivantes:

1. Pas de changement aux ordonnances actuelles.
2. L'adoption, par le Canada, en 1989, des règlements des États-Unis de 1988, règlements visant à réduire les émissions des camions.

Cette analyse prédit que la deuxième alternative coûtera environ $34 millions annuellement, dont $23 millions seront dépensés pour les camions de CPBV de moins de 14000 livres. Cet argent servira à munir les camions de cette catégorie de convertisseurs catalytiques, de pompes d'air aux collecteurs d'échappement et à défrayer les coûts inhérents à une consommation accrue d'essence de 5 %, consommation accrue due au retardement de l'allumage. Le coût approximatif qui devra être défrayé par les canadiens pour effectuer ces transformations pour les années 1990 à 2000 inclusivement est de $357 millions. Si les règlements canadiens de 1995 pour les moteurs diesels sont mis en application, le coût initial de $357 millions pourra atteindre les $493 millions puisque plus d'acheteurs choisiront les camoins utilisant l'essence au lieu de ceux utilisant le diesel, ceci en vue d'éviter les problèmes associés aux filtres des particules.

Les camions utilisant le diesel comme carburant

Cette analyse estime le coût pour Canadiens pour les trois alternatives suivantes:

1. Pas de changement aux ordonnances actuelles.
2. Adoption des règlements des États-Unis de 1988 comme règlements canadiens de 1989.

3. Adoption des règlements des États-Unis de 1994 comme règlements Canadiens de 1995.

Cette analyse n'a pas traité les règlements américains de 1991 parce qu'il y a de très fortes chances que leur mise à exécution soit retardée, peut-être jusqu'en 1994, ceci pour permettre aux manufacturiers de développer l'équipement requis pour se conformer aux exigences du dit règlement.

Si les règlements canadiens actuels ne changent pas, cette analyse prévoit une diminution du coût que doivent défrayer les cammionneurs d'à peu près $100 millions annuellements. Dans les années 1990 à 2000 inclusivement, on prévoit une réduction totale d'environ $477 millions, occasionnée en grande partie par une consommation réduite de 2.6 milliards de litres de carburant diesel. Cette amélioration de la consommation de carburant résultera de l'installation des équipements suivants:

- meilleur système d'injection
- injection de temps variable
- turbocompresseur avec refroidisseur

Comparativement, si les règlements canadiens actuels demeurent inchangés, les règlements proposés pour 1989 auront comme effet d'augmenter les coûts des contribuables d'environ $65 millions annuellement. Pour les années 1990 à 2000, le coût est estimé à $141 millions, ceci dû à l'augmentation de la consommation du carburant occasionnée par l'injection retardée nécessaire pour respecter les règlements. On estime que la consommation supplémentaire du carburant diesel sera d'environ 1.4 milliard de litres.

Dans l'optique où aucun changement n'est fait aux règlements actuels, les règlements proposés pour 1995 coûteraient aux Canadiens environ $346 millions par année. Pour les années 1990 à 2000 inclusivement, le coût total s'élèvera à près de $2 milliards. Ces

prévisions tiennent compte de la grande possibilité que les propriétaires de camions moyens, moyens-lourds et lourds enlèveraient de leurs camions les équipements qui réduisent la pollution et ce dans le but d'éviter les problèmes opérationnels qu'ils causent et pour réduire la consommation de carburant diesel, réduction estimée à $200 millions par année. Les propriétaires de camions légers essayeront d'obtenir le même résultat par une simple voie d'évitement du filtre des particules et un réglage du moteur. Par conséquent, l'intention des règlements visant à améliorer la qualité de l'air sera probablement vaine.

Les autobus urbains

Cette analyse fait une comparaison des coûts d'opération d'autobus urbains fonctionnant avec les carburant suivants:

1. Carburant diesel
2. Propane
3. Gaz naturel liquide ou comprimée
4. Méthanol

Le rapport conclu qu'il y a peu de différence entre le coût d'opération d'un tel véhicule avec l'un ou l'autre de ces carburants. Ils sont donc tous viables pour se conformer aux règlements canadiens proposés pour 1995 dans la catégorie de véhicules autobus.

Valeur Actualisée

Cette analyse fait le calcul de la valeur actualisée des règlements canadiens de 1989 et 1995. Ces calculs sont effectués à un taux de 10% pour l'année 1986 et ce pour les coûts qui seront encourus pendant les années 1990 à 2000 inclusivements. Les coûts sont les suivants:

1. $312 million p.v., règlement de 1989
2. $900 millions p.v., règlements de 1995.

EXECUTIVE SUMMARY

Gasoline Powered Trucks

This analysis considers two regulatory options:

1. No change to existing standards.
2. The adoption of U.S. 1988 exhaust emission standards as the Canadian 1989 standards for gasoline powered trucks.

For option (2) this analysis forecasts an annual cost of about $34 million, of which $23 million would be spent on trucks with a gross vehicle weight of less than 14 000 pounds to provide catalytic converters, air pumps to the exhaust manifolds, and about 5% more gasoline consumed because of retarded ignition timing. The estimated cost to Canadians for the years 1990 to 2000 inclusive is $357 million. If the proposed Canadian 1995 regulations for diesel engines are implemented, this cost could likely rise to $493 million because more purchasers would buy gasoline powered trucks instead of diesel powered trucks to avoid the problems associated with the particulate traps.

Diesel Powered Trucks

This analysis has estimated the cost to Canadians of the following three options:

1. No change to present Canadian regulations.
2. Adoption of U.S. 1988 regulations as Canadian 1989 regulations.
3. Adoption of U.S. 1994 regulations as Canadian 1995 regulations.

This analysis did not consider adoption of U.S. 1991 standards because there is a very high probability that their implementation will be delayed, perhaps to 1994 in order to allow manufacturers to develop the satisfactory equipment necessary to comply with them.

If present Canadian standards are not changed, this analysis forecasts a reduction in cost to Canadian truckers of about $100 million annually. During the years 1990 to 2000 inclusive, this reduction is forecasted to total about $477 million, caused mainly by reduced consumption of about 2.6 billion litres of diesel fuel. This improved fuel economy results from the following equipment which will likely be installed on the trucks.

1. Improved injection systems
2. Variable injection timing
3. Turbocharging and air to air aftercooling.

Compared with no change to present Canadian standards, the proposed Canadian 1989 standards would increase costs to Canadians by about $64 million annually. During the years 1990 to 2000 the cost is forecasted to be about $141 million, almost all of it from increased fuel consumption caused by retarded injection timing needed to meet the standards. The extra diesel fuel consumed for these 11 years is estimated to be 1.4 billion litres.

Compared with no change to present Canadian standards, the proposed Canadian 1995 standards would increase costs to Canadians by about $346 million annually. During the years 1990 to 2000 inclusive, the total costs are forecasted to be about $2 billion. These forecasted costs take into account that owners of medium, medium heavy, and heavy trucks could remove from their trucks the pollution control equipment in order to avoid the operational problems it causes and in order to save fuel estimated to cost $200 million annually. Owners of light trucks could achieve the same result by simply by-passing the particulate traps and retuning their engines. As a result, the intent of the standards to improve air quality would likely be defeated.

Urban Buses

This analysis compares the cost of operating urban buses on the following fuels:

1. Diesel Fuel
2. Propane
3. Liquified or compressed natural gas
4. methanol

It concludes that there is little difference in operating cost, no matter which fuel is used and therefore, propane, natural gas, and methanol are all viable options for meeting proposed Canadian 1995 standards for buses.

Present Values

This analysis calculates the present value of the Canadian 1989 and 1995 regulations discounted at 10% to the year 1986, for costs incurred during years 1990 to 2000 inclusive to be:

1. $312 million p.v. for 1989 regulations
2. $900 million p.v. for 1995 regulations.

1.0 Purpose

The purpose of this report is to forecast the incremental cost to Canada, based on the allocation of resources, of implementing standards limiting the emissions from trucks and buses having a gross vehicle weight exceeding 8500 pounds.

1.1 Background

1.1.1 The U.S. Regulation

The U.S.A. introduced emission regulation 40CFR Parts 86 and 600 on the Federal Register on March 15th, 1985 entitled "Control of Air Pollution from New Motor Vehicle and New Motor Engines; Gaseous Emission and Particulate Emission Regulations". The regulation applies to gasoline and diesel powered vehicles.

2.0 Introduction

Since these proposed regulations will affect the behaviour of Canadians in the future, the costs incurred by the regulations must be forecasted. In this analysis, the forecast extends to the year 2000.

In order to make the forecast realistic, it must begin in a year when all of the parameters under consideration are known. In this analysis the year 1984 was selected as the beginning of the forecast. Since the increase in crude oil prices has been negative between 1984 and 1985, and since the change in Consumer Price Index has been only 4% between 1984 and 1985, there is almost no difference in cost whether measuring in 1984 dollars or 1985 dollars. For that reason, the figures quoted in this analysis may be considered to be in 1985 dollars.

The methodology employed is straightforward. Firstly, the change in cost to Canadians caused by the implementation of regulations in the U.S.A. limiting emissions from heavy duty trucks is forecasted from 1990 to the year 2000, assuming that no changes are made to the present Canadian regulations. This calculation is appropriate because no heavy duty diesel engines are manufactured in Canada, and consequently, Canadians will be affected by regulations in the U.S.A. which affect Canada's major source of diesel engines.

Secondly, the change in cost to Canadians caused by implementation of proposed Canadian 1989 regulations is forecasted to the year 2000 on the same basis as the first forecast was made. The incremental cost for the proposed Canadian 1989 regulations is then obtained by subtracting the first forecast from the second forecast.

Thirdly, the change in cost to Canadians caused by implementation of proposed Canadian 1995 regulations is forecasted to the year 2000 on the same basis as the first forecast was made. The incremental cost for the proposed Canadian 1995 regulations is then obtained by subtracting the first forecast from this third forecast. This methodology is pictured in the following chart:

ANALYTICAL METHODOLOGY

Regulatory Situation	Years	
1. Change in cost with no change to Canadian regulations	1990	2000
2. Change in cost with proposed Canadian 1989 regulations	1990	2000
3. Incremental cost incurred by proposed Canadian 1989 regulations Situation 2 minus situation 1	1990	2000
4. Change in cost with proposed Canadian 1995 regulations	1990	2000
5. Incremental cost incurred by proposed Canadian 1995 regulations Situation 4 minus situation 1	1990	2000

Price is the money paid by a purchaser to a seller in exchange for a good or service. Whenever possible, the prices quoted in this report are for transactions occurring in the year 1984.

Estimating the price is a difficult problem when no transactions have occurred. In this analysis, the price quoted by the seller, who is one side of the transaction, has been used to calculate the estimated cost to the purchaser. A strong argument could be made that competitive pressures will force sellers to lower their prices from these quoted figures. The Environmental Protection Agency of the U.S. Government has tried to forecast this lower price by forecasting the out-of-pocket costs to the manufacturer, and then by assuming that prices would eventually decline to those estimated figures.

This analysis could not form an opinion on the liklihood of prices dropping to the values estimated by E.P.A. because detailed estimates were not available showing the name of suppliers of each component nor the quoted price provided by each supplier. The following comparison helps the reader form his own conclusion.

ESTIMATED PRICE OF PARTICULATE TRAPS

(Canadian Dollars)

Market Segment	EPA	Seller	Ratio
Heavy Duty Trucks	$800	$6600	.12
Medium Heavy Duty Trucks	$385	$4000	.10
Medium Duty Trucks	$385	$3000	.13
Light Duty Trucks	$370	$1000	.37

If the numbers from EPA had been used instead of the sellers' prices, the cost of particulate traps required by the proposed Canadian 1995 regulations would have changed to (millions of Canadian dollars):

Market Segment	Tables 7,8,9,10	Ratio	EPA
Heavy Duty Trucks	623.7	.12	74.8
Medium Heavy Duty Trucks	183.2	.10	18.3
Medium Duty Trucks	86.4	.13	11.2
Light Duty Trucks	37.1	.37	13.7
Totals	930.4		118.0

This difference is too great to be accounted for by estimating errors. The reader must form his own opinion on whether or not prices would likely fall 87% as a result of competitive pressures and whether or not EPA's prices are really belove the manufacturers' costs.

3.0 COST OF CHANGES IN THE U.S.A.

No diesel engines for trucks are manufactured in Canada. All such engines are imported, mainly from the U.S.A. The important question to Canada becomes "What will be the changes in selling price of diesel engines sold in Canadian trucks because the United States has implemented its regulations limiting emissions?" The following changes in prices were forecasted by the manufacturers in their submissions to EPA in the U.S.A. They are, at present, the best estimate of what the manufacturers plan to add to their prices to recover the costs of 1988 regulations. When Canadians pay these increases, they are, in effect, allocating resources to truck engines.

3.1 Cummins' Prices

Their price increases range from $100 U.S. to $800 U.S. depending on the size of the engine, to cover costs of the following additional equipment:[3]

1. variable injection timing;
2. low temperature after cooling;
3. increased fuel injection pressure;
4. combustion chamber modifications;
5. electronically controlled fuel system.

The increase in price in Canadian dollars, based on this information for each market segment is:

Heavy (Greater than 33,000 lbs)	$1100 Cdn.
Medium Heavy	$1100 Cdn.
Medium	$ 600 Cdn.
Light	$ 137 Cdn.

[3] Regulatory Impact Analysis, Oxides of Nitrogen Pollutant Specific Study and Summary and Analysis of Comments, 1985, P.3-44

3.2 Ford's Prices

Ford estimated $350 U.S. for the following additional equipment:[4]

1. improved fuel injection system;
2. variable injection timing;
3. turbo charging;
4. air-to-air aftercooling.

The increase in price in Canadian dollars based on this information for the market segment where Ford offers its own engines is:

Medium	$480 Cdn.

3.3 International Harvester's Prices

IHC estimated $337 U.S. for the following additional equipment:[4]

1. electronically controlled fuel systems;
2. air-to-air after-cooling;
3. engine cooling system changes.

The increase in price in Canadian dollars based on this information for the market segment where IHC offers its own engines is:

Medium	$460

3.4 General Motors' Prices

General Motors did not forecast its prices. As a best approximation, the Cummins prices will be used for G.M. engines.

[4] Ibid: P.3-44

4.0 ADDITIONAL COSTS TO CANADIANS ASSUMING NO CHANGES TO CANADIAN STANDARDS

The additional equipment described in the previous section will be added to the Canadian engines, whether or not Canada has more restrictive emission standards for trucks because:

1. The cost of not adding the equipment to the small volume of engines sold in Canada is prohibitive. The Canadian market is only about 10% of the total North American market.

2. That equipment can be used to increase the fuel economy of the Canadian engines by about 6% if Canada does not impose more restrictive emissions standards on trucks.[5]

Using the prices quoted in the previous section, the average increase in cost per engine is weighted in accordance with the manufacturers' market shares. The reader should note that Ford and International Harvester do not make diesel engines for heavy and medium heavy trucks.

4.1 Unit Cost of Equipment on Light Trucks

A price of $137 has been used for this analysis, based on the price quoted by Cummins. No other manufacturers quoted prices.

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[5] Ricardo Consulting Engineers, DP.85/1244, July 8, 1985, P.2

4.2 Unit Cost of Equipment on Medium Trucks

The manufacturer's Canadian market shares and incremental prices are approximately:

Manufacturer	Share	Price	Share x Price
Ford	15%	$480	$ 72
G.M.	32%	$600	$192
I.H.	35%	$460	$161
Other	18%	$600	$108
		Composite Price	$533

4.3 Unit Cost on Heavy and Medium Heavy Trucks

The manufacturer's shares of the Canadian market for engines in these trucks are approximately:

Manufacturer	Share	Price
Cummins	50%	$1100
DDA (GM)	20%	Unknown
Caterpillar	15%	Unknown
Mack	10%	Unknown
Other	5%	Unknown

Based on these figures, the additional cost per truck is estimated to be $1100 Cdn.

4.4 Calculation of the Tax-out Price of Diesel Fuel[6]

The representative retail price of diesel fuel in 1984 was 44.6 cents per litre. The composite provincial taxes (weighted average) is approximately 19% ad valorem. The Canadian federal tax is 2¢ per litre excise tax, and 2.9¢ per litre sales tax. The estimated tax-out price per litre is 31.2 cents.

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6 Energy, Mines and Resources Canada, Transportation Energy Data Book Edition 3, 1985, P.86.

4.5 Calculation of the Tax-out Price of Gasoline[6]

The representative retail price of gasoline in 1984 was 48.4 cents per litre. The composite provincial taxes (weighted average) is approximately 17.5% ad valorem. The Canadian federal tax was 1.5¢ per litre excise, and 3.2¢ per litre sales tax. The estimated tax-out price per litre is 35.9 cents.

4.6 Calculation of Cost Reduction from Fuel Savings

The installation of the above mentioned equipment is forecasted to reduce fuel consumption on new trucks by 3% in 1990, 4% in 1991, 5% in 1992, and 6% in 1993 and thereafter.[7]

The reduction in costs from reduced fuel consumption are based on the annual fuel consumption in Table 1 multiplied by the sales in Table 2, and then multiplied by the tax-out price of fuel. The equipment costs are obtained by multiplying the unit cost previously calculated by the sales in Table 2. These numbers are added together in Table 3 to show the net cost to Canadians of no change to the present Canadian regulations.

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6 Energy, Mines and Resources Canada, Transportation Energy Data Book Edition 3, 1985, P.86.

7 Hydra International, Review of the Current Activities in Heavy Truck Research and Development, page 3-11, July 1985.

TABLE 1

HDDV Fuel Economy, Average Annual Distance Travelled, and Vehicle Life Estimates

Vehicle Category	Fuel Economy (1/100 km)	Annual Distance (km)	Vehicle Life (years)	Annual Fuel Consumption L
LHDDV	15.6	17 700	10	2 760 L
MHDDV	29.4	48 300	9	14 200 L
HHDDV	39.8	104 600	8	41 630 L

Source: EPA (1985) and Pilorusso Research Associates Inc., Control of Heavy Duty Vehicle Emissions, 1985, P.49,

TABLE 2

FORCAST OF SALES OF TRUCKS WITH DIESEL ENGINES

Year	Light Trucks GVW 8500 lbs or more	Medium	Medium Heavy	Heavy
1990	8 200	4 500	6 400	13 000
1991	9 400	4 500	7 000	13 500
1992	9 500	5 000	7 000	14 000
1993	10 700	5 000	7 800	14 500
1994	10 800	5 500	8 400	14 500
1995	12 100	6 000	9 000	14 500
1996	14 600	6 000	9 500	15 500
1997	17 200	6 000	9 900	15 500
1998	19 800	6 400	9 900	16 000
1999	22 400	6 800	9 900	16 500
2000	25 000	7 200	10 800	17 000

Source: Energy, Mines and Resources Canada, Trends in the Candian Truck Market, P.30, 36

R237/4734R

TABLE 3

ESTIMATED NET COST TO CANADIANS OF NO CHANGE

(millions of dollars)

	Light Trucks GVW 8500 or more			Medium Trucks		
Year	Equipment	Fuel Savings	Net Cost	Equipment	Fuel Savings	Net Cost
1990	1.1	-.2	.9	2.4	-.6	1.8
1991	1.3	-.5	.8	2.4	-1.4	1.0
1992	1.3	-.5	.4	2.7	-2.5	.2
1993	1.5	-1.4	0	2.7	-3.8	-1.1
1994	1.5	-2.0	-.5	3.0	-5.3	-2.3
1995	1.7	-2.6	- .9	3.2	--6.9	-3.7
1996	2.0	-3.4	-1.4	3.2	-8.5	-5.3
1997	2.4	-4.2	-1.8	3.2	-10.1	-6.9
1998	2.7	-5.3	-2.6	3.4	-11.8	-8.4
1999	3.0	-6.4	-3.5	3.6	-12.4	-8.8
2000	3.4	-7.5	-4.2	3.8	-12.7	-8.7
Totals	21.9	-34.0*	-12.8	33.6	-76*	-42.2

Glossary:

1. Equipment refers to the additional price paid by Canadians for the following additional equipment installed on trucks as a result of U.S. emissions regulations:

   a) variable injection timing
   b) low temperature aftercooling
   c) increased fuel injection pressure
   d) combustion chamber modifications
   e) elecronically controlled fuel system

2. Fuel Savings refers to the costs associated with the reduction in fuel consumption resulting from the installation of the equipment listed above

3. Negative numbers are savings rather than costs.

R237/4734R

TABLE 3

(continued)

ESTIMATED NET COST TO CANADIANS OF NO CHANGE

(millions of dollars)

Year	Medium Heavy Equipment	Medium Heavy Fuel Savings	Medium Heavy Net Cost	Heavy Equipment	Heavy Fuel Savings	Heavy Net Cost
1990	7.0	-.9	6.1	14.3	-5.0	9.2
1991	7.7	-2.1	5.6	14.8	-12.0	2.7
1992	7.7	-3.6	4.1	15.4	-21.1	-5.8
1993	8.6	-5.7	2.9	16.0	-32.4	-16.5
1994	9.2	-7.9	1.3	16.0	-43.7	-27.8
1995	9.9	-10.3	-.4	16.0	-55.0	-39.1
1996	10.5	-12.8	-2.3	16.5	-66.7	-50.3
1997	10.9	-15.5	-4.6	17.0	-78.8	-61.9
1998	10.9	-18.1	-7.2	17.6	-86.2	-68.7
1999	10.9	-19.9	-9.0	18.0	-92.4	-74.4
2000	12.0	-20.7	-8.7	18.7	-96.2	-77.5
Totals	105.3	-117.5*	-12.2	180.3	-589.5*	-410.1
				Total Cost		-477.3

* Total Cost of Fuel Saved = $\$817 \times 10^6$

* Quantity of Diesel Fuel Saved = 2.61×10^9 litres

5.0 COST TO CANADIANS OF PROPOSED 1989 REGULATIONS

5.1 Descripiton of the 1989 Regulations

5.1.1 Implementation date - 1990 model year, 2 years after the U.S. regulations.

5.1.2 Test Fuel - Phillips No. 2 diesel fuel for trucks; Phillips No. 1 diesel fuel for buses; engine manufacturers may obtain authorization from Transport Canada to use test fuel with a maximum of .05% sulfur.

5.1.3 Test Cycle - The same dynamic test cycle as is used in the U.S.A.

5.1.4 Maximum permitted emissions:[1]

Hydrocarbons (HC)	.48 grams per megajoule
Carbon monoxide (CO)	5.77 grams per megajoule
Nitrogen oxides (NO_x)	2.23 grams per megajoule
Particulates	.22 grams per megajoule

5.2 Criterion of Acceptance:

Each manufacturer prove that the model of engine which he proposes to sell in Canada, when new, (less than 100 hours in operation) emits at less than the prescribed maximum rate when run on the prescribed test cycle. Proof would be test data provided for trucks in a manner similar to what is provided for cars; or a certificate from EPA in the U.S.A. that the engine meets the standards set by EPA.

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1 Pilorusso Research Associates Inc., Control of Heavy Duty Vehicle Emissions, 1985, P.36

5.3 Excluded from the Canadian regulations would be any provision in the U.S. regulation for in-use enforcement. The incremental costs do not include costs incurred by the following provisions which are part of regulations in the U.S.A.:

a) useful life (full life vs. half life)
b) deterioration factors
c) emissions averaging
d) allowable maintenance

5.4 Discussions

5.4.1 Sulfur Concentration

Caterpillar[2] argues that a test fuel with less than .05% sulfur is necessary because the sulfates on the filter paper during the test procedure combine with the water vapour in the air to double or triple its weight, depending on the air's relative humidity. Since the relative humidity is not well controlled during the test procedure, the repeatability of compliance testing using high sulfur fuels is not adequate for engines near the limits specified in the regulation. Repeatability is adequate with diesel fuel containing less than .05% sulfur.

5.4.2 Selective Enforcement Audit

The Environmental Protection Agency uses selective enforcement audit to ensure that the diesel engines continue to perform during their useful life, within the regulations. Using this procedure, EPA tests engines obtained from truckers, at various mileage intervals. In order for the engine to qualify, a very accurate log must be kept of the truck's operation, and the engine must be operated and

[2] Federal Register October 15, 1984 Docket No A-80-16 P.10

maintained precisely in accordance with the manufacturers' instructions. These instructions make no provisions for the use of cold weather starting aides, high sulfur fuels, low cetane fuels, high aromatic fuels, or operating temperatures below -25°C. All of these conditions prevail normally in Canada. Therefore, there would be no Canadian trucks which would qualify for U.S. selective enforcement audit. With no qualifiable trucks, the Canadian government could not effectively adopt the provisions of the U.S. regulation concerning selective enforcement audit. Defining in-use enforcement procedures within the engine's useful life is such a provision which could not be adopted.

The provincial governments have jurisdiction over truckers within their provinces. Consequently, they have responsibility for licensing and inspecting truckers. Any in-use inspection, such as selective enforcement audit, would be within the provincial government's jusrisdiction. For this reason, the Canadian federal government cannot institute selective enforcement audit. Without selective enforcement audit, the U.S. regulations concerning useful life, deterioration factors, allowable maintenance, and in-use enforcement procedures, are not appropriate for Canada.

5.4.3 Emissions Averaging

The U.S. regulations permit an engine manufacturer to sell engines whose emissions exceed the regulations providing he also sells a sufficient number of engines with emissions less than the regulatory limits, such that the average emissions of all his engines within the class are less than the regulatory limits. Since many provinces allow truckers 140,000 lbs./gross vehicle weights while many states in the U.S.A. only allow smaller gross vehicle weights, Canadian truckers purchase a larger proportion of trucks with larger engines than do their counterparts in the U.S.A. The Canadian market is about 10% of the U.S. market. These two factors create a situation where the average emissions of a manufacturer's Canadian sales would

be different than the average emissions of his U.S. sales. The Canadian market is sufficiently small that even if Canada allowed emissions averaging, the engine manufacturers could not take any other corrective action except to withdraw from the Canadian market, those engines which did not meet Canadian regulations. In this situation, some Canadian manufacturers of specialized trucks would be deprived of a satisfactory source of diesel engines.

For these reasons, all of the engine manufacturers have complained that emissions averaging is not suitable to Canada.

5.5 Estimation of Fuel Penalty

If the proposed Canadian 1990 regulations are implemented, Canadians will likely receive the engines described in the previous section, but tuned to meet the Canadian standards. The rectangular area bounded by 6.0 and .60 in Figure 1 shows that Cummins, Canada's largest supplier of heavy duty truck engines, can just meet the proposed regulations with most of their engines currently under development. The major change reguired is a reduction of NO_x from about 8 grams per brake horsepower-hour (gm/BHP-HR) to about 6 gm/BHP-HR.

Figure 3 shows that with a diesel fuel with a cetane number of 45, the injection would have to be retarded from about 18° before top dead centre (BTDC) to about 13° BTDC. The change in fuel consumption is from .41 brake specific fuel consumption (BSFC) to .42 BSFC. This change is an increase in fuel consumption of 2.5%. This figure co-incides with the testimony provided by Cummins to EPA when they quoted the following fuel penalties:[8]

Large engines	3%
Medium engines	2%
Small engines	1%

7 Hydra International, Review of the Current Activities in Heavy Truck Research and Development, P 3 - 7

8 Cummins Engine Company Inc. Public Docket Number A-80-18 1984, P.16

FIGURE 1

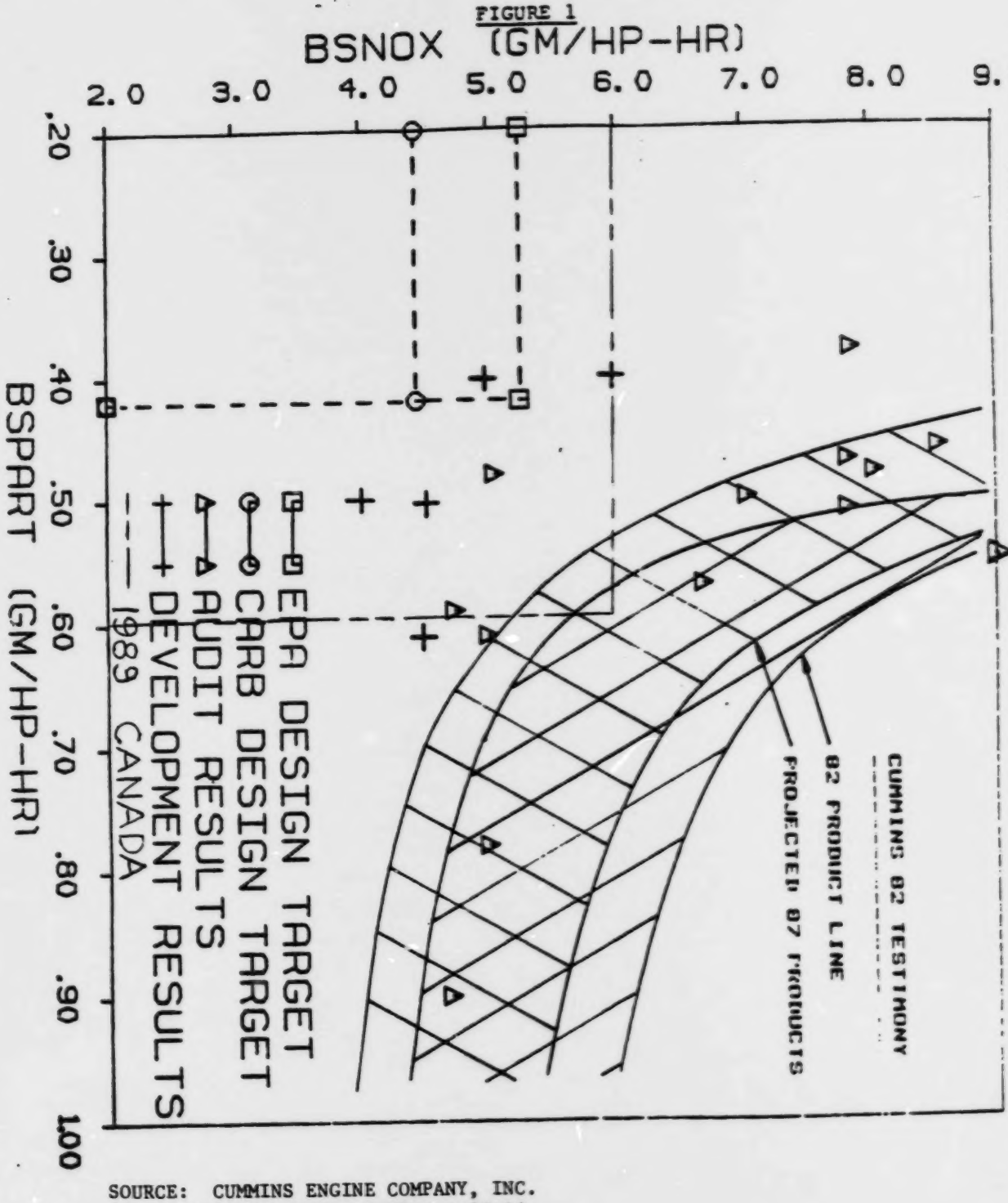

FIGURE 1

SOURCE: CUMMINS ENGINE COMPANY, INC.
E.P.A. PUBLIC DOCKET NUMBER A-80-18
Columbus, Indiana, December 17, 1984

FIGURE 2

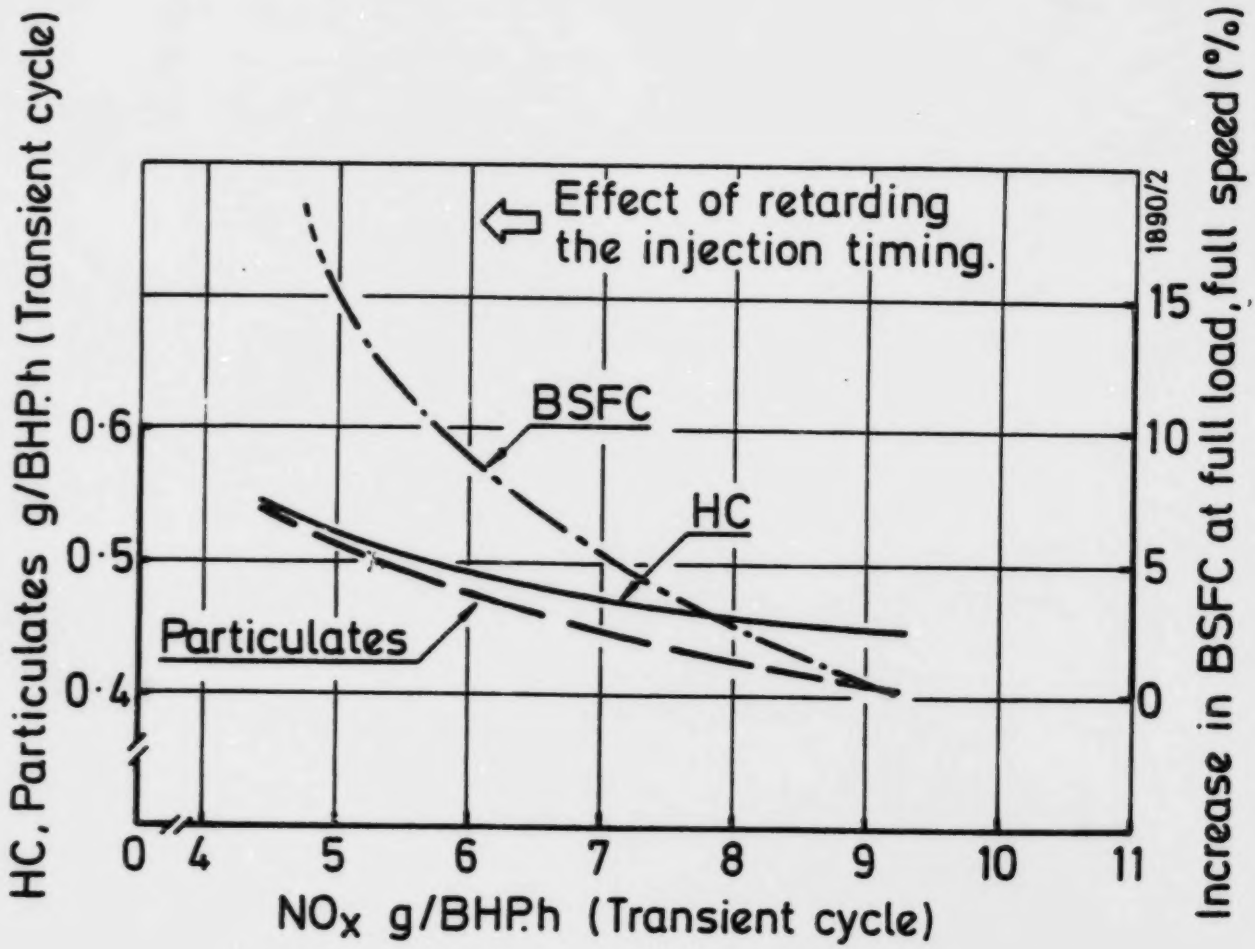

FIG.2. TRADE-OFF BETWEEN NO_x, HC, PARTICULATES AND BRAKE SPECIFIC FUEL CONSUMPTION. MEDIUM DUTY DIRECT INJECTION TURBOCHARGED AND AFTERCOOLED ENGINE. HC, NO_x AND PARTICULATES MEASURED OVER U.S. TRANSIENT CYCLE.

RICARDO CONSULTING ENGINEERS, EXHAUST EMISSION REGULATION FOR HEAVY DUTY DIESEL ENGINES D.P.85/1244, July 8, 1985

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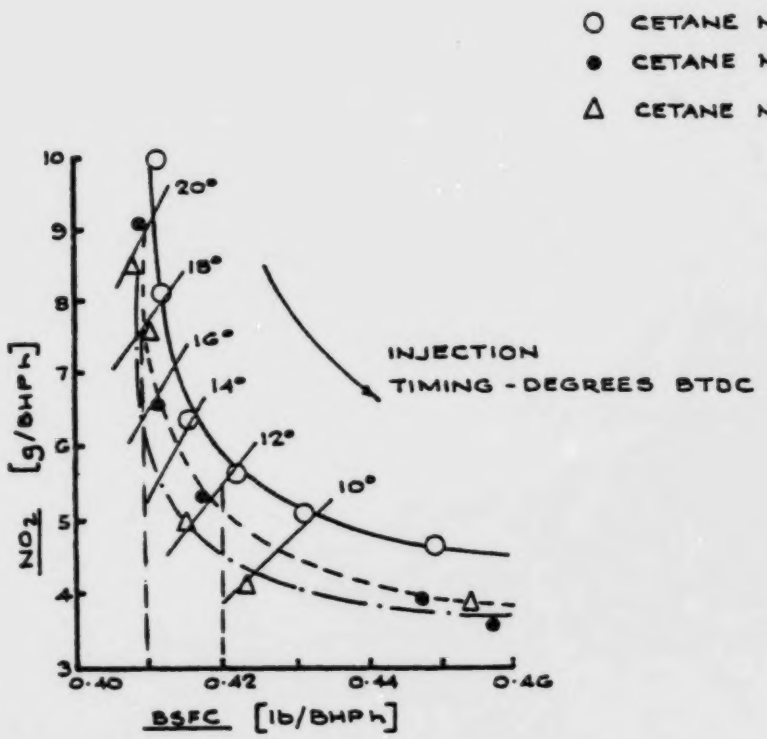
FIG. No. 27
Drg. No. S. 8083
Date FEB.' 81

THE INFLUENCE OF CETANE NUMBER UPON $BSNO_2$ - B.S.F.C. TRADE-OFF AT CONSTANT SPEED AND LOAD REF. 55



ENGINE:
SINGLE CYLINDER, 4 STROKE, DIRECT INJECTION
4·75" BORE x 4·75" STROKE CR. 14·2:1

FIGURE 3

RICARDO CONSULTING ENGINEERS, EXHAUST EMISSION REGULATION FOR HEAVY DUTY DIESEL ENGINES
D.P. 85/1244, July 8, 1985

Figure 2, which relates HC, NO_x, particulates, and fuel efficiency indicates a change in BSFC of between 4% and 5% for the Canadianized standards. It supports the opinion that the penalties quoted by Cummins are conservative and are probably the best that can be achieved by presently available technology.

5.6 Estimated Cost to Canadians of 1989 Regulations For Years 1990 to 2000

The estimated cost to Canadians if 1989 regulations are implemented is the sum of the costs of:

1. Equipment to meet U.S. 1988 standards.
2. Fuel savings from the equipment.
3. Fuel penalty of Canadian 1989 standards.

These costs are shown on Table 4.

In order to obtain the incremental cost of the 1989 regulations over the cost of no change to the present regulations, the costs previously calculated for no change in regulations are subtracted from the sum of the costs listed above. This calculation is shown on Table 5.

TABLE 4

COST OF 1989 REGULATIONS
(Millions of Dollars)

Light Trucks

Year	Equipment	Fuel Savings	Fuel Penalty	Total
1990	1.1	-.2	.1	1.0
1991	1.3	-.5	.1	.9
1992	1.3	-.5	.2	1.0
1993	1.5	-1.4	.3	.4
1994	1.5	-2.0	.4	-.1
1995	1.7	-2.6	.5	-.4
1996	2.0	-3.4	.6	-.8
1997	2.4	-4.2	.8	-1.0
1998	2.7	-5.3	.9	-1.7
1999	3.0	-6.4	1.1	-2.3
2000	3.0	-7.5	1.3	-2.8
Totals	21.9	-34.0	6.3	-5.8

TABLE 4

(continued)

COST OF 1989 REGULATIONS

(Millions of Dollars)

Medium Trucks

Year	Equipment	Fuel Savings	Fuel Penalty	Total
1990	2.4	-.6	.4	2.2
1991	2.4	-1.4	.8	1.8
1992	2.7	-2.5	1.2	1.4
1993	2.7	-3.8	1.7	.6
1994	3.0	-5.3	2.2	-.1
1995	3.2	-6.9	2.7	-1.0
1996	3.2	-8.5	3.2	-2.1
1997	3.2	-10.1	3.8	-3.1
1998	3.4	-11.8	4.3	-4.1
1999	3.6	-12.4	4.5	-4.3
2000	3.8	-12.7	4.8	-4.1
Totals	33.6	-76.0	29.6	-12.8

TABLE 4

(continued)

COST OF 1989 REGULATIONS

(Millions of Dollars)

Medium Heavy Trucks

Year	Equipment	Fuel Savings	Fuel Penalty	Total
1990	7.0	-.9	.9	7.0
1991	7.7	-2.1	1.8	7.4
1992	7.7	-3.6	2.8	6.9
1993	8.6	-5.7	3.7	6.6
1994	9.2	-7.9	4.9	6.2
1995	9.9	-10.3	6.1	5.7
1996	10.5	-12.8	7.3	5.0
1997	10.9	-15.5	8.6	4.0
1998	10.9	-18.1	9.9	2.7
1999	10.9	-19.9	10.4	1.4
2000	12.0	-20.7	10.9	2.2
Totals	105.3	-117.5	67.3	55.1

TABLE 4

(continued)

COST OF 1989 REGULATIONS

(Millions of Dollars)

Heavy Trucks

Year	Equipment	Fuel Savings	Fuel Penalty	Total
1990	14.3	-5.0	5.1	14.4
1991	14.8	-12.0	10.3	13.1
1992	15.4	-21.1	15.8	10.1
1993	16.0	-32.4	21.4	5.0
1994	16.0	-43.7	27.1	-.7
1995	16.0	-55.0	32.7	-6.3
1996	16.5	-66.7	38.6	-11.6
1997	17.0	-78.8	44.6	-17.2
1998	17.6	-86.2	45.8	-22.8
1999	18.0	-92.4	47.0	-27.4
2000	18.7	-96.2	48.2	-29.3
Totals	180.3	-589.5	336.6	-72.7
			Grand Total	-36.2

TABLE 5

INCREMENTAL COST OF 1989 REGULATIONS

(Millions of Dollars)

	Light Trucks			Medium Trucks			Medium Heavy Trucks			Heavy Trucks		
Year	Cost 1990 Regulation	Cost No Regulation	Incremental Cost	Cost 1990 Regulation	Cost No Regulation	Incremental Cost	Cost 1990 Regulation	Cost No Regulation	Incremental Cost	Cost 1990 Regulation	Cost No Regulation	Incremental Cost
1990	1.0	.9	.1	2.2	1.8	.4	7.0	6.1	.9	14.4	9.2	5.2
1991	.9	.8	.1	1.8	1.0	.8	7.4	5.6	1.8	13.1	2.7	10.4
1992	1.0	.4	.6	1.4	.2	1.2	6.9	4.1	2.8	10.1	-5.8	15.9
1993	.4	0.	.4	.6	-1.1	1.7	6.6	2.9	3.7	5.0	-16.5	21.5
1994	-.1	-.5	.4	-.1	-2.3	2.2	6.2	1.3	4.9	-.7	-27.8	27.1
1995	-.4	-.9	.5	-1.0	-3.7	2.7	5.7	-.4	6.1	-6.3	-39.1	32.8
1996	-.8	-1.4	.6	-2.1	-5.3	3.2	5.0	-2.3	7.3	-11.6	-50.3	38.7
1997	-1.0	-1.8	.8	-3.1	-6.9	3.8	4.0	-4.6	8.6	-17.2	-61.9	44.7
1998	-1.7	-2.6	.9	-4.1	-8.4	4.3	2.7	-7.2	9.9	-22.8	-68.7	45.9
1999	-2.3	-3.5	1.2	-4.3	-8.8	4.5	1.4	-9.0	10.4	-27.4	-74.4	47.0
2000	-2.8	-4.2	1.4	-4.1	-8.9	4.8	2.2	-8.7	10.9	-29.3	-77.5	48.2
Total	-5.8	-12.8	7.0	-12.8	-42.4	29.6	55.1	-12.2	67.3	-72.7	-410.1	337.4

Total Incremental Cost of 1989 Regulations is $441.3 million

R237/4734R

6.0 INCREMENTAL COST TO CANADIANS OF THE PROPOSED CANADIAN 1989 REGULATIONS

6.1 Discussion

The diesel engine manufacturers have indicated that an improvement in fuel economy of as little as 2% could sway major fleet buyers to change their choice of engine. Therefore, as soon as one supplier provided Canadian specific engines with improved fuel economy, all would have to do it to retain market share.

Figure 1 shows the EPA design target for NO_x at 5.2 g/BHP-HR compared with 6.0 g/BHP-HR in the Canadianized regulation. Figure 2 shows that changing the design target from 6.0 g/BHP-HR to 5.2 g/BHP-HR changes the fuel economy penalty from 8% to 12%, an additional penalty of 4%.

Truck manufacturers have indicated that if Canada imposed the Canadianized regulations, they would prefer to supply engines tuned to meet the U.S. regulations, unless competition forced them to provide Canadian specific engines. If Canadians were to receive the engines tuned to U.S. regulations, the resulting fuel penalty would be approximately double the one used in the previous analysis. Table 6 shows the implications of this situation.

6.2 Sample Calculations for Diesel Fuel Costs

The sample calculation of the increase in diesel fuel costs for the year 1998 for heavy duty trucks with engines tuned to U.S. 1988 Regulations is done by first estimating the extra fuel consumed by new trucks sold in the year 1998 and then adding to it the extra fuel consumed by other heavy trucks still on the road in 1998 which were tuned to U.S. 1988 Regulations. In order to simplify the calculation, the distance travelled by the new trucks is assumed to be at an average rate of 104,600 km. per year. The reader who takes

exception to this assumption may, instead, consider the calculation to be for new trucks sold the previous year and just completing their first full year of service.

For the new trucks, the extra diesel fuel consumed because of the regulation equals the truck sales volume for the year 1998 multiplied by annual distance travelled multiplied by quantity of fuel consumed per kilometre multiplied by the fuel penalty measured in per cent, multiplied by the tax out price of fuel. The tax-out price represents the allocative effect. The tax is considered a transfer payment.

These values are:

Sales of heavy duty trucks in the year 1998 = 16,000 units.
Average distance travelled per year per vehicle = 104,600 km.
Average fuel consumption per vehicle per kilometre = $.398 1/km.
Tax out price of fuel in 1985 dollars = $.312

Annual fuel costs
= 16,000 x 104,600 x .398 x .06 x .312 = $12.57 x 10^6

To this cost for new trucks must be added the extra costs incurred by the other heavy trucks already on the road which are tuned to U.S. 1988 standards. Since heavy trucks have an expected life of eight years, this figure equals the costs calculated for the previous years' heavy duty trucks less the costs incurred by trucks more than eight years old.

These figures are:

Costs of extra fuel for year 1997	$89.2 x 10^6
Costs of extra fuel for year 1991	$10.2 x 10^6

Heavy duty truck fuel penalty costs for year 1998
= $(12.57 + 89.2 - 10.2) x 10^6 = $91.6 x 10^6

The total fuel penalty costs for year 1998 equals the sum of fuel penalty costs for year 1998 for each class of truck.
= $(1.8 + 8.6 + 19.8 + 91.6) x 10^6 = $121.8 x 10^6

TABLE 6

INCREMENTAL COST TO CANADIANS OF ENGINES
TUNED TO U.S. 1988 REGULATIONS

(Millions Canadian Dollars)

Year	Light	Medium	Medium Heavy	Heavy	Total
1990	.2	.8	1.8	10.2	13
1991	.2	1.6	3.6	20.6	26
1992	.4	2.4	5.6	31.6	40
1993	.6	3.4	7.4	42.8	54.2
1994	.8	4.4	9.8	54.2	69.2
1995	1.0	5.4	12.2	65.4	84.0
1996	1.2	6.4	14.6	77.2	99.4
1997	1.6	7.6	17.2	89.2	115.6
1998	1.8	8.6	19.8	91.6	121.8
1999	2.2	9.0	20.8	94.0	126.0
2000	2.6	9.6	21.8	96.4	130.4
Totals	12.6	59.2	134.6	673.2	879.6

7.0 THE INCREMENTAL COST TO CANADIANS OF PROPOSED 1995 REGULATIONS

The technology necessary to meet these proposed regulations has not yet been developed. There is no assurance that it will ever be developed. Recognizing this problem, EPA of the U.S. government has informally agreed to review the state of technology existing in 1990 and decide whether or not to delay implementation in the U.S.A. of regulations scheduled for 1991 and 1994 to limit emissions from diesel engined trucks.

The diesel engine manufacturers have said that they will temporarily stop selling their engines in Canada if Canada imposes regulations which are more restrictive than those prevailing in the U.S.A.

This cost analysis assumes that the Canadian government will delay imposing any regulations which would cut off Canadian truckers from a reliable source of new engines, and forecasts the earliest date of implementation to be in 1995.

7.1 Description of 1995 Regulations

7.1.1 Implementation date - 1995 model year, 1 year after the U.S. regulations.

7.1.2 Test fuel - Phillips No. 2 diesel fuel for trucks; Phillips No. 1 diesel fuel for buses; engine manufacturers may obtain authorization from Transport Canada to use test fuel with a maximum of .05% sulfur.

7.1.3 Test cycle - the same dynamic test cycle as is used in the U.S.A.

7.1.4 Maximum permitted emissions:

NO_x	1.86	grams per megajoule
HC	.48	grams per megajoule
CO	5.77	grams per megajoule
Particulates	.037	grams per megajoule

7.1.5 Criterion of Acceptance

Each manufacturer prove that the model of engine which he proposes to sell in Canada, when new, (less than 100 hours in operation) emits at less than the prescribed maximum rate when run on the prescribed test cycle. Proof would be test data provided for trucks in a manner similar to what is provided for cars; or a certificate from EPA in the U.S.A. that the engine meets the standards set by EPA.

7.1.6 Excluded from the Canadian regulations would be any provision in the U.S. regulation for in-use enforcement. The incremental costs do not include costs incurred by the following provisions which are part of the regulations in the U.S.A.:

a) useful life (full life vs. half life);
b) deterioration factors;
c) emissions averaging;
d) allowable maintenance;

7.2 Forcast of Sales of Trucks with Diesel Engines

The regulations proposed for 1995 would discourage many customers from buying trucks with diesel engines. Instead, they would buy gasoline engines in their trucks in order to avoid the many difficulties posed by the regulations and described later in the analysis.

TABLE 7

FORECAST OF SALES OF TRUCKS WITH DIESEL ENGINES
ASSUMING ADOPTION OF 1995 REGULATIONS

Year	Light Trucks GVW greater than 8500 lbs.	Medium	Medium Heavy	Heavy
1990	5 860	3 600	5 600	13 000
1991	5 900	3 600	5 950	13 500
1992	5 940	3 900	5 950	14 000
1993	5 980	3 900	6 300	14 500
1994	6 020	4 200	6 650	14 500
1995	6 060	4 500	7 000	14 500
1996	6 100	4 500	7 350	15 000
1997	6 140	4 500	7 700	15 000
1998	6 180	4 800	7 700	16 000
1999	6 260	5 100	7 700	16 500
2000	6 300	5 400	8 400	17 000

7.3 Calculation of Fuel Penalty

Engine manufacturers have indicated that if Canada adopts the regulations previously described for 1995, they would sell as much as is possible in Canada, engines tuned to meet the U.S. regulations. Engines saleable in the U.S.A. because of emissions averaging would be withdrawn from the Canadian market if they failed to meet Canadian standards. As a consequence, the new diesel engines sold in Canada after 1995 would be designed to meet the emissions targets of:

No_x	1.67 grams per megajoule
Particulate	.15 grams per megajoule with a particulate trap added to the engine and achieving at least 80% efficiency.

Note: 1.67 grams per megajoule equals 4.5 grams per brake horsepower-hour.

In Figure 1, repeated here for convenience, the rectangle identified as CARB design target shows that Cummins, Canada's largest supplier of heavy duty truck engines, cannot meet the proposed 1995 emissions regulations with any engines currently under development. The requirement to reduce NO_x from about 8 grams per brake horsepower hour to 4.5 grams per brake horsepower hour is shown in figure 2 (also repeated for convenience) to cause a fuel penalty in excess of 20%. Figure 3 (also repeated for convenience), indicates that brake specific fuel consumption would increase from .41 to .48, an increase of 17%. Such a penalty would encourage buyers to tamper with their engines in order to recover the lost fuel economy.

Figure 4 suggests that 10% to 15% exhaust gas recirculation at an injection timing of about 8° before top dead centre could reduce NO_x emissions from 17 grams per hour to about 14 grams per hour, or approximately 20%. This improvement would be sufficient to allow the timing to be set at about 8° BTDC.

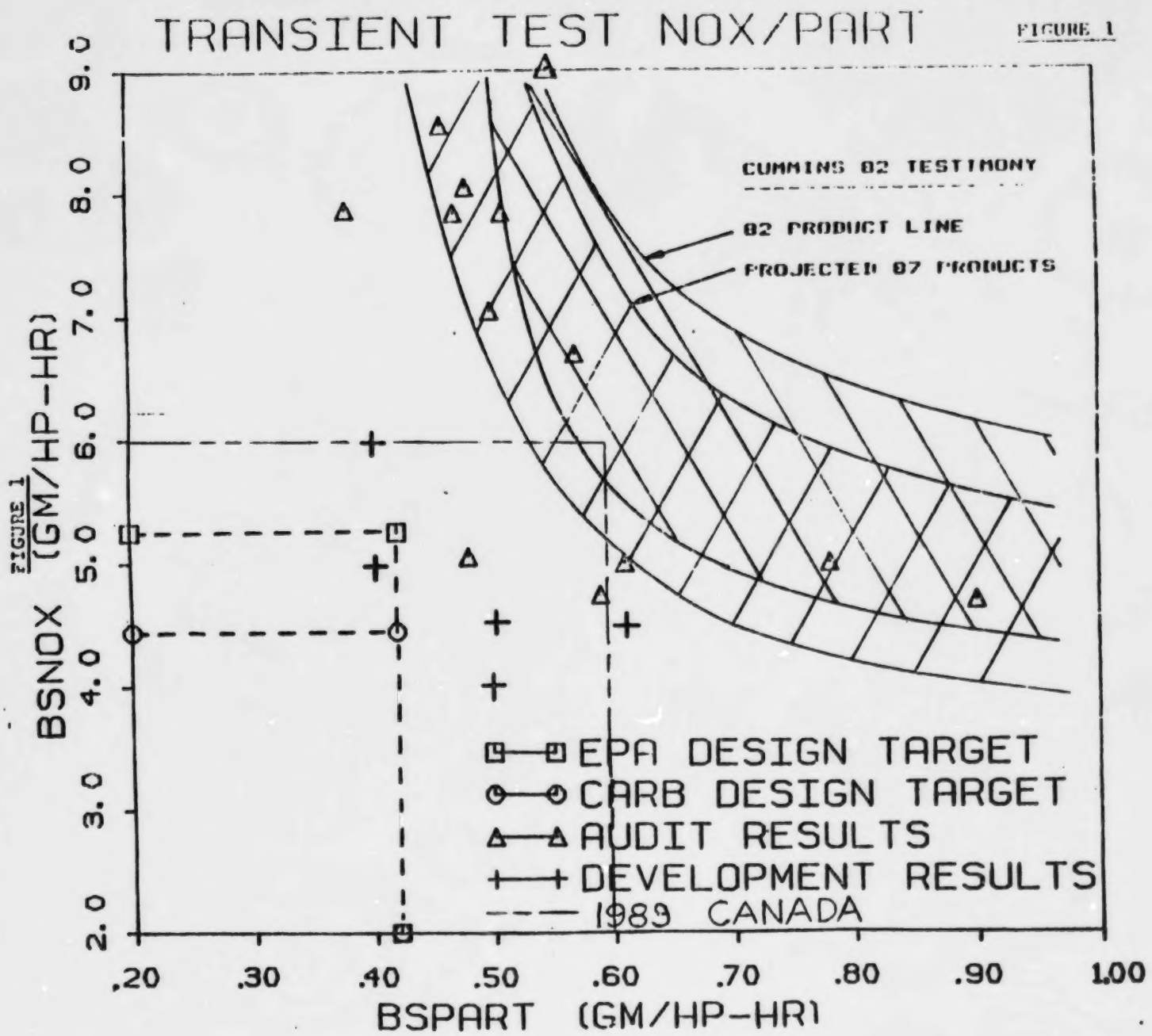

TRANSIENT TEST NOX/PART
FIGURE 1
CUMMINS 82 TESTIMONY
82 PRODUCT LINE
PROJECTED 87 PRODUCTS
EPA DESIGN TARGET
CARB DESIGN TARGET
AUDIT RESULTS
DEVELOPMENT RESULTS
1983 CANADA
BSNOX (GM/HP-HR)
BSPART (GM/HP-HR)
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
.20
.30
.40
.50
.60
.70
.80
.90
1.00

FIGURE 1

FIGURE 2

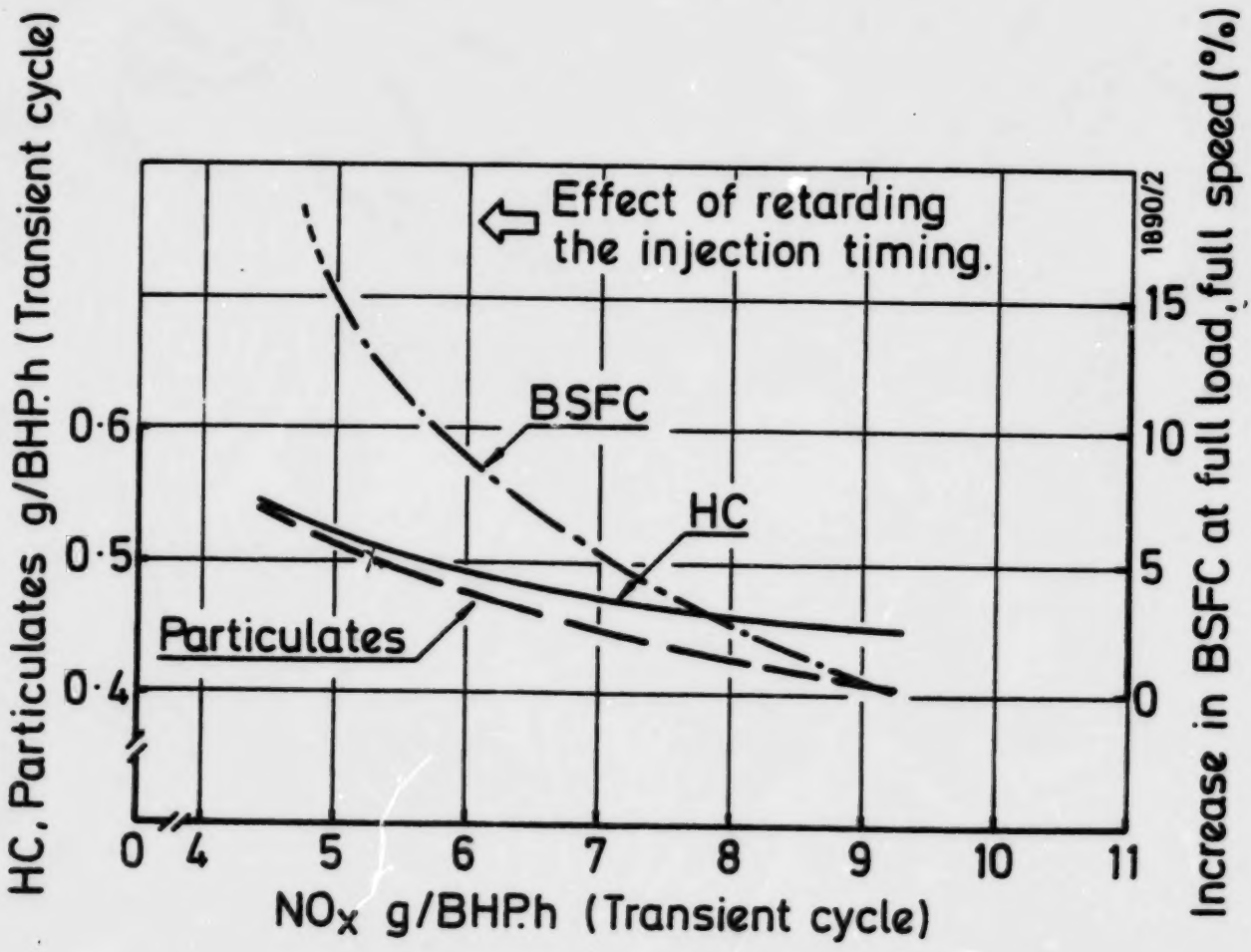


FIG.2. TRADE-OFF BETWEEN NO_x, HC, PARTICULATES AND BRAKE SPECIFIC FUEL CONSUMPTION. MEDIUM DUTY DIRECT INJECTION TURBOCHARGED AND AFTERCOOLED ENGINE. HC, NO_x AND PARTICULATES MEASURED OVER U.S. TRANSIENT CYCLE.

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FIG. No. 27
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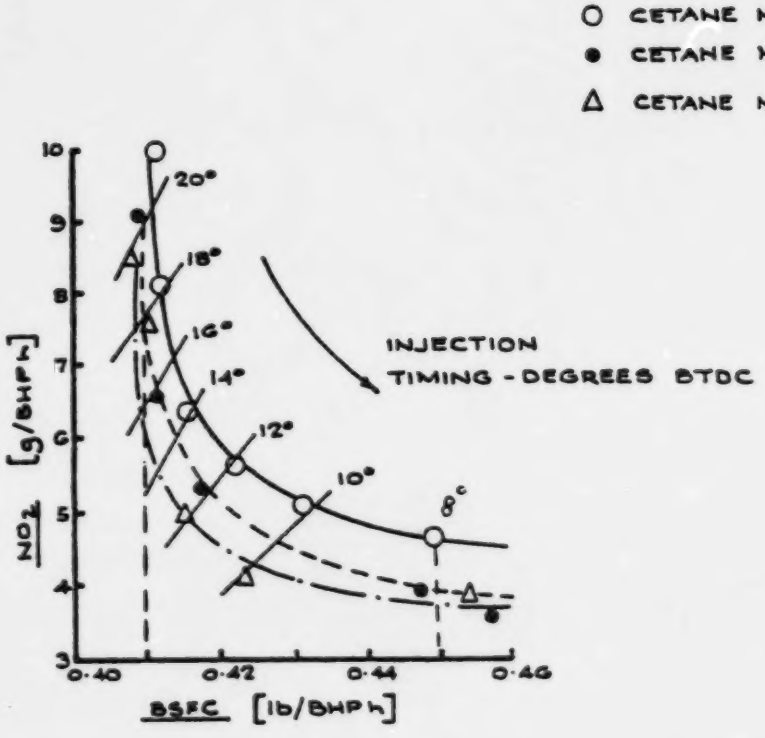
Date FEB.' 81

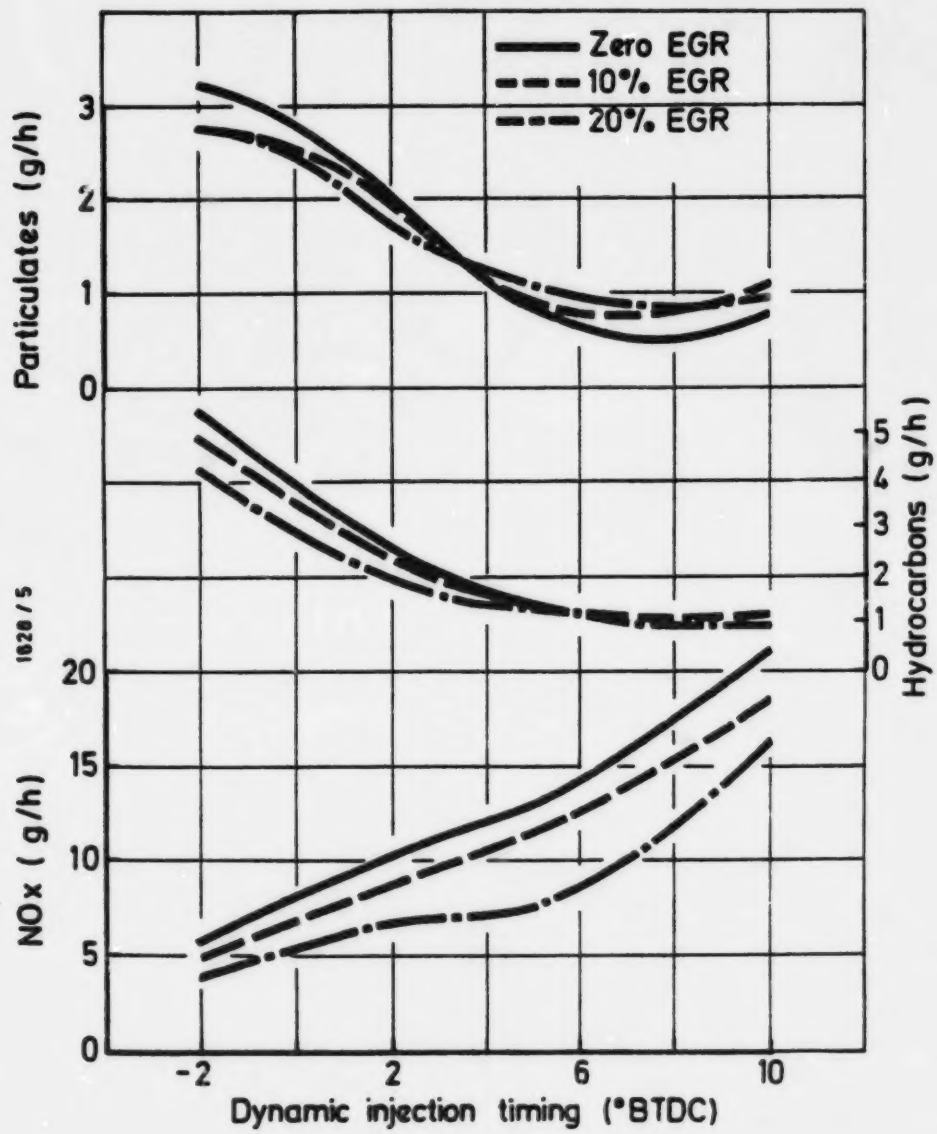
THE INFLUENCE OF CETANE NUMBER UPON $BSNO_2$ - B.S.F.C. TRADE-OFF AT CONSTANT SPEED AND LOAD REF. 55



ENGINE:
SINGLE CYLINDER, 4 STROKE, DIRECT INJECTION
4·75" BORE x 4·75" STROKE CR. 14·2:1

FIGURE 3

FIGURE 4



PARTICULATE, NOx AND HYDROCARBON EMISSIONS AT 650 REV/MIN, NO LOAD

RICARDO CONSULTING ENGINEERS, EXHAUST EMISSION REGULATIONS FOR HEAVY DUTY DIESEL ENGINES
D.P. 85/1244, July 8, 1985

Figure 3 indicates that at 8° BTDC brake specific fuel consumption would increase from .41 to .45, an increase of 10%. This seems correct as engines presently sold in California without traps but meeting the CARB regulations are incurring a fuel penalty of 10% over engines sold in other parts of the U.S.A. and a penalty of 13% over Canadian engines.

The particulate traps incur, by themselves, a fuel penalty of about 3% to:

a) overcome additional back pressure posed by the trap;
b) to provide either fuel or electricity to burn off the accumulated particulate.

Based on these calculations and experience, the fuel economy penalty is forecasted to be 13% for the proposed Canadian 1995 regulations for diesel engines.

In addition to this penalty, there is the fuel economy penalty of the trucks purchased with gasoline engines which would have otherwise been purchased with diesel engines if the regulations had not been implemented.

7.4 Calculations of the Price of Traps

As described in the previous section, the new diesel engines meeting the Canadian 1995 emission standards will require particulate traps and exhaust gas recirculation. None of the traps or controls for EGR will be manufactured in Canada. Therefore, the costs Canadians pay for them will be the prices quoted by the manufacturers. In their testimony to E.P.A., the manufacturers quoted the prices which are used in the following calculation.

7.4.1 Cost of Traps for Heavy Duty Trucks

After 1995, a large portion of Canadian diesel fuel is expected to contain .5% sulfur and 40% aromatics. This combination will produce a high level of particulate emissions which will tend to plug the traps at temperatures of -40°C in January and February. In order to minimize the problem, truck manufacturers have said that Canadian heavy duty trucks will likely need dual particulate traps. The following cost estimates, are based on that opinion.

MANUFACTURES' QUOTED PRICES[9]

Manufacturer	Share of Market	Price	Weighted Price
Cummins	50%	$5 620 U.S.	$2 810
DDA (GM)	20%	$4 000 U.S.	$ 800
Caterpiller	15%	$No quote	$ 600
Mack	10%	$No quote	$ 400
Other	5%	$No quote	$ 200
		Composite Price	$4 810

In the absence of a quote, a price of $4 000 U.S. is estimated for traps not priced by the manufacturer.

The price for dual traps on heavy duty trucks is estimated to be (4 810 x 1.37) = $6 600 Canadian.

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9 Environmental Protection Agency, Regulatory Impact Analysis Oxides of Nitrogen Pollutant Specific Study, 1985, P.3-66.

7.4.2 COST OF TRAPS FOR MEDIUM HEAVY TRUCKS[9].

Manufacturer	Share of Market	Price	Weighted Price
Cummins	50%	$3 270 U.S.	$1 635
DDA (GM)	20%	$2 300 U.S.	$ 460
Caterpiller	15%	No quote	$ 395
Mack	10%	No quote	$ 230
Other	5%	No quote	$ 165
		Composite Price	$2 885

A price of $2 300 U.S. is estimated for traps without a price quoted by the manufacturer.

The price for single traps on medium heavy trucks is estimated to be $4 000 Canadian.

7.4.3 COST FOR MEDIUM TRUCKS[9].

Manufacturer	Share of Market	Price	Weighted Price
Ford	15%	$2 200 U.S.	$ 330
GM	32%	$2 300 U.S.	$ 736
IH	35%	$2 070 U.S.	$ 725
Other	18%	$2 200 U.S.	$ 396
		Composite Price	$2 187

A price of $2 200 has been assumed for other.

9. Ibid

The price for single traps on medium trucks is estimated at $3 000 Canadian.

7.4.4 Cost for Light Trucks[9].

Only General Motors quoted a price for light trucks, estimating a range of $575 U.S. to $900 U.S. Therefore, the price for a single trap on light trucks is estimated to be:

$$1.37 \left(\frac{575 + 900}{2}\right) = \$1\ 000 \text{ Canadian}$$

9. Ibid

7.4.5 Estimated Cost to Canadians of 1995 Regulations For Years 1990 to 2000

The estimated cost to Canadians if 1995 regulations are implemented is the sum of the costs of:

1. Equipment to meet U.S. 1988 standards.
2. Fuel savings from the equipment.
3. Fuel penalty of Canadian 1990 standards (1990-1995).
4. Fuel penalty of Canadian 1995 standards.
5. Fuel penalty from gasoline engines replacing diesel engines.
6. Traps and EGR.
7. Installation of conventional mufflers and retune engines on Heavy Duty Trucks.

In order to obtain the incremental cost of the 1995 regulations over the cost of no change to the present regulations, the costs previously calculated for no change in regulations are subtracted from the sum of the costs listed above.

The following Tables make these calculations.

TABLE 8

COST OF 1995 REGULATIONS

(Millions of Dollars)

Light Trucks

Year	Equipment	Fuel Savings	Fuel Penalty	Penalty Gasoline	Cost of Trap	Total
1990	.8	-.1	.1	1.0		1.8
1991	.8	-.4	.1	2.6		3.1
1992	.8	-.7	.2	4.2		4.5
1993	.8	-1.0	.3	6.3		6.4
1994	.8	-1.3	.4	8.5		8.4
1995	.8	-1.6	1.1	11.2	6.1	17.6
1996	.8	-1.9	1.8	15.0	6.1	21.8
1997	.8	-2.2	2.5	19.9	6.1	27.1
1998	.9	-2.5	3.2	26.0	6.2	33.8
1999	.9	-2.8	3.9	33.2	6.3	41.5
2000	.9	-3.0	4.5	40.6	6.3	49.3
Totals	9.1	-17.5	18.1	168.5	37.1	215.3

Glossary:

3. Fuel Penalty is increased in diesel fuel consumed and caused by retarding the injection timing to meet the 1995 Regulations.

4. Penalty Gasoline is the difference in the rate of gasoline consumed versus diesel fuel consumed by gasoline powered trucks which would likely have been diesel powered if no 1995 regulations had been implemented.

5. Cost of Trap is the unit cost of the trap multiplied by the number of trucks sold in a particular year.

TABLE 9

COST OF 1995 REGULATIONS
(Millions of Dollars)

Medium Trucks

Year	Equipment	Fuel Savings	Fuel Penalty	Penalty Gasoline	Cost of Trap	Total
1990	1.9	-.2	.1	2.1		3.9
1991	1.9	-.3	.2	4.2		6.0
1992	2.1	-1.2	.4	6.7		8.0
1993	2.2	-2.2	.7	9.3		10.0
1994	2.4	-3.4	1.1	12.3		12.4
1995	2.4	-4.6	3.7	15.7	13.5	30.7
1996	2.4	-5.8	6.3	19.2	13.5	35.6
1997	2.4	-7.0	8.9	22.7	13.5	40.5
1998	2.6	-8.3	11.7	26.4	14.4	46.8
1999	2.7	-9.5	14.6	27.8	15.3	50.9
2000	2.9	-10.8	18.4	30.3	16.2	57.0
Totals	25.9	-53.3	66.1	176.1	86.4	301.0

TABLE 10

COST OF 1995 REGULATIONS
(Millions of Dollars)

Medium Heavy Trucks

Year	Equipment	Fuel Savings	Fuel Penalty	Penalty Gasoline	Cost of Trap	Total
1990	6.2	-.8	.8	1.8		8.0
1991	6.5	-1.9	1.7	4.3		10.6
1992	6.5	-3.2	2.6	6.7		12.6
1993	7.0	-4.9	3.5	10.2		15.8
1994	7.3	-6.5	4.4	14.2		19.4
1995	7.7	-8.6	8.6	18.9	28.0	54.6
1996	8.1	-10.6	12.9	23.8	29.4	63.6
1997	8.5	-12.3	17.5	28.9	30.8	73.4
1998	8.5	-14.8	22.1	32.2	30.8	78.8
1999	8.5	-16.1	25.9	34.8	30.6	83.7
2000	9.2	-16.4	29.8	38.0	33.6	94.2
Totals	84	-96.1	129.8	213.8	183.2	514.7

TABLE 11

COST OF 1995 REGULATIONS
(Millions of Dollars)

Heavy Trucks

Year	Equipment	Fuel Savings	Fuel Penalty	Penalty Gasoline	Cost of Trap	Total
1990	14.3	-5.1	5.1			14.3
1991	14.8	-12.1	10.3			13.0
1992	15.4	-21.2	15.8			10.0
1993	16.0	-32.5	21.4			4.9
1994	16.0	-43.8	27.1			-0.7
1995	16.5	-55.1	51.6		95.7	108.7
1996	16.5	-66.8	77.0		99.0	125.7
1997	17.0	-78.9	103.2		102.3	143.6
1998	17.6	-86.3	125.1		105.6	162.0
1999	18.0	-92.4	147.6		108.9	182.1
2000	18.7	-96.2	171.0		112.2	205.7
	180.8	-590.4	755.2		623.7	969.3

Total Cost of Fuel Penalty $\$969.2 \times 10^6$

Quantity of Diesel Fuel Consumed 3.1×10^9 litres

Total Cost of gasoline penalty $\$558.4 \times 10^6$

Quantity of gasoline consumed 1.1×10^9 litres

TABLE 12

INCREMENTAL COST OF 1995 REGULATIONS AS INTENDED

(Millions of Dollars)

	Light Trucks			Medium Trucks			Medium Heavy Trucks			Heavy Trucks		
Year	Cost 1995 Regulation	Cost No Regulation	Incremental Cost	Cost 1995 Regulation	Cost No Regulation	Incremental Cost	Cost 1995 Regulation	Cost No Regulation	Incremental Cost	Cost 1995 Regulation	Cost No Regulation	Incremental Cost
1990	1.8	.9	.9	3.9	1.8	1.1	8.0	6.1	1.9	14.3	9.2	5.1
1991	3.1	.8	2.3	6.0	1.0	5.0	10.6	5.6	5.0	13.0	2.7	10.3
1992	4.5	.4	4.1	8.0	.2	7.8	12.6	4.1	8.5	10.0	-5.8	15.8
1993	6.4	0.	6.4	10.0	-1.1	11.1	15.8	2.9	12.9	4.9	-16.5	21.4
1994	8.4	-.5	8.9	12.4	-2.3	14.7	19.4	1.3	18.1	-.7	-27.8	27.1
1995	17.6	-.9	18.5	30.7	-3.7	34.4	54.6	-.4	55.0	108.7	-39.1	147.8
1996	21.8	-1.4	23.2	35.6	-5.3	40.9	63.6	-2.3	65.9	125.7	-50.3	176.0
1997	27.1	-1.8	28.9	40.5	-6.9	47.4	73.4	-4.6	78.0	143.6	-61.9	205.5
1998	33.8	-2.6	36.4	46.8	-8.4	55.2	78.8	-7.2	86.0	162.0	-68.7	230.7
1999	41.5	-3.5	45.0	50.9	-8.8	59.7	83.7	-9.0	92.7	182.1	-74.4	256.5
2000	49.3	-4.2	53.5	57.0	-8.9	65.9	94.2	-8.7	102.9	205.7	-77.5	283.2
Total	215.3	-12.8	228.1	301.0	-42.4	343.2	514.7	-12.2	526.9	969.3	-410.1	1379.4

Total Incremental Cost of 1995 Regulations Implemented as Intended = $\$2,478 \times 10^6$

8.0 Sample Calculation for Cost of Gasoline

The sample calculation of the increase in cost of gasoline for the year 1999 for medium duty trucks with engines tuned to U.S. 1988 Regulations is done by first estimating the extra gasoline consumed by new trucks sold in the year 1999 and then adding to it the extra gasoline consumed by other gasoline powered medium trucks still on the road in 1999 which were tuned to U.S. 1988 Regulations. In order to simplify the calculation, the distance travelled by the new trucks is assumed to be at an average rate of 48,300 km. The reader who takes exception to this assumption may, instead, consider the calculation to be for new trucks sold the previous year and just completing their first full year of service.

For the new trucks, the extra gasoline consumed because of the regulation equals the sales volume for the year 1999 shown in Table 2, minus the sales volume for the year 1999 shown in Table 6, both multiplied by the annual distance travelled times the rate of fuel consumption of medium trucks with gasoline engines, times the price of gasoline, all minus the sales volume for the year 1999 shown in table 2, minus the sales volume for the year 1999 shown in Table 6, both multiplied by the annual distance travelled times the rate of fuel consumption of medium trucks with diesel engines times the price of diesel fuel.

The values of these parameters are:
Sales of medium trucks in the year 1999 from Table 2 are 6,800 units
Sales of medium trucks in the year 1999 from Table 6 are 5,100 units
Annual distance travelled equals 48,300 km.
Rate of fuel consumption gasoline engines = .389 l/km.
Rate of fuel consumption diesel engines = .294 l/km.
Price of gasoline equals $.359. Price of diesel fuel equals $.312

This calculation can be simplified to:
(trucks switching to gasoline) x (annual kilometres driven)
x fuel consumption gasoline x price gasoline - fuel consumption
diesel x price of diesel fuel)

Fuel costs of new medium trucks with gasoline engines in 1999 = (6800 - 5100) (48,300) (.389 x .359 - .294 x .312) = $3.9 x 10^6

To the previous costs for new trucks must be added the extra costs incurred by the additional other gasoline powered medium trucks already on the road which are tuned to 1988 standards. Since medium trucks have an expected life of nine years, this figure equals the costs calculated for the previous years medium trucks less the costs incurred by trucks more than 9 years old.

For the penalty gasoline in the year 1999, this calculation is 26.4 plus 3.5 minus 2.1 equals $27.8 million. Table 9 contains the corresponding figures.

9.0 Cost of Replacing Particulate Traps

This analysis forecasts the replacement of the particulate traps by conventional mufflers within the first 24 months of a medium, medium heavy, or heavy truck's operation for two reasons, one technical, one financial.

9.1 Technical

The particulate traps are likely to be plugged by a mixture of ash, carbon, and sulfur. This mixture is similar to what occurs in high temperature coal fired furnaces. Some of the ash, carbon, and sulfur formed during the combustion of the diesel fuel crystallizes out, and adheres to the filtering media in the trap in such a way that it entraps small bubbles of air. The entrapped air forms a large portion of the volume of material adhering to the filter, and in combination with ash, carbon and sulfur is a very poor conductor of heat so that during the regenerating process, not all of the combination is burned off. Some of it remains. Over a period of 12 to 24 months it eventually plugs the filter sufficiently to cause malfunction of the diesel engine. This phenomenon has already been observed in traps provided by Mercedes Benz on their diesel powered automobiles in California.[10]

9.2 Financial

Examination of figures 1, 2 and 3 shows that if the particulate trap is removed and the fuel injection timing is advanced from 8° BTDC to 20° BTDC, a fuel economy saving of about 16% can be achieved. Since fuel is approximately 11%[11] of truckers' revenues, the overall saving to truckers is about 1.8% of truckers revenues. The average profit of truckers is only 2.5% of revenue, and in the highly competitive segment of general frieght where most of the firms operate, the profit is only .5%. In order to gain market share of

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10 Ricardo Consulting Engineers, Verbal communication

11 Statistics Canada, Catalogue 53-222

general freight, some truckers, especially small companies or owner-operators, would likely replace the traps with conventional mufflers and retune their engines in order to reduce their fuel costs; and then lower their prices. Once a few competitors make these changes, all of the competitors will have to make the change in order to remain in business because the fuel economy saving is equal to or greater than the net profit.

9.3 Alternative Course of Action

Currently designed particulate traps provide a method during the regeneration cycle by which diesel engine exhaust bypasses the filtering media and goes directly to the atmosphere. In order to overcome the fuel penalty and additional maintenance caused by particulate traps, many owner-operators and small companies would likely adjust the controls on the particulate trap so that the exhaust bypass pipe remains permanently open and the supply of diesel fuel or electricity for the regeneration of the particulate trap remains permanently shut off. These adjustments are easy to make and cheaper than replacing the trap, and therefore, are most likely to be carried out on light duty diesel trucks. For that reason, the replacement of traps with conventional mufflers has not been costed for light duty trucks.

The fuel economy savings have not been forecasted for light duty diesels because most owners will not spend the money to retune their engines.

9.4 Cost of Mufflers

The following two quotations were received for installing new mufflers on heavy duty trucks:

Mack $1 971
IHC $1 411

For this analysis, the lower figure of $1 411 will be used for heavy duty trucks.

Using costs from IHC, the cost of installing new exhaust pipes and mufflers on medium and medium heavy trucks is estimated at $844.

9.5 Annual Fuel Savings to the Trucker

The price of diesel fuel is estimated to be 44.6¢ per litre. The average annual distance travelled per truck is estimated at 104,600 kilometres for heavy duty trucks and 48,300 kilometres for medium and medium-heavy trucks.

The average fuel consumption is estimated at:

39.8 litres per 100 km for heavy duty trucks
29.4 litres per 100 km for medium and medium-heavy trucks

By multiplying price per litre by average annual distance by average fuel consumption the reduction in annual cost of fuel per truck is estimated to be:

$2 970.00 for heavy trucks
$1 013.00 for medium and medium-heavy trucks

On trucks less than three years old with high utilization, the annual savings could easily be 50% greater than the above figures, because most of them travel 50% farther.

9.6 Cost/Benefit Comparison

The number of months needed to recover the cost of replacing the traps with mufflers is:

4.7 months for heavy duty trucks
10 months for medium and medium heavy trucks

9.7 Incremental Allocative Costs of Replacing Traps With Mufflers

The incremental allocative cost of replacing particulate traps with mufflers on heavy and medium heavy trucks is shown in the attached chart, and is based on the replacement occurring within 24 months of purchasing the truck. Costs are millions of dollars.

TABLE 13

(Millons of Dollars)

	Heavy Duty Trucks			Medium Trucks and Medium Heavy Trucks			
Year	Trap Removal	Fuel Savings	Incremental Cost	Trap Removal	Fuel Savings	Incremental Cost	Total Incremental Cost
1996	20.5	-30.1	-9.6	9.7	-8.2	1.5	-8.1
1997	21.2	-61.3	-30.1	10.0	-16.6	-6.6	-36.7
1998	21.9	-93.51	-61.3	10.3	-25.2	-14.9	-76.2
1999	22.6	-126.7	-93.5	10.6	-34.1	-23.5	-117.0
2000	23.3	-161.0	-126.7	10.8	-43.2	-32.4	-159.1

Glossary:

7. Trap Removal is the cost of removing traps and retuning engines 12 to 24 months after purchase.

8. Fuel Savings is the cost of diesel fuel saved as a result of retuning the engine.

9. Incremental Cost is the sum of the Trap Removal and Fuel Savings.

TABLE 14

INCREMENTAL COST OF 1995 REGULATIONS WITH TAMPERED TRAPS

(Millions of Dollars)

Year	Summed Incremental Cost	Incremental Trap Replacement	Total Cost
1990	9.0	-	9.0
1991	22.6	-	22.6
1992	36.2	-	36.2
1993	51.8	-	51.8
1994	68.8	-	68.8
1995	255.7	-	255.7
1996	306.0	-8.1	297.9
1997	359.8	-36.7	323.1
1998	408.3	-76.2	332.1
1999	453.9	-117.0	336.9
2000	505.5	-159.1	346.4
	2 477.6	-397.1	2 080.5

10.0 COST TO CANADIANS OF PROPOSED 1989 REGULATIONS FOR GASOLINE ENGINES

10.1 Description of the 1989 Regulations

Implementation date - 1989 model year, 1 year after the U.S. regulations.

Test Fuel - Indolene, the same as in the U.S.A.

Test Cycle - The same dynamic test cycle as is used in the U.S.A., except that engine manufacturers have the option of testing their trucks with GVW of 8,500 lbs to 14,000 lbs using the light-duty test cycle, already implemented in the U.S.A.

Maximum permitted emissions: Light-duty vehicles
(LIGHT DUTY TEST CYCLE) - GVW (LESS THAN 14,000 lbs.)

Hydrocarbons (HC)	.25 g/km
Carbon monoxide (CO)	4.35 g/km
Nitrogen Oxides (Nox)	.62 g/km
Particulates	Not applicable

Maximum permitted emissions: Light - heavy-duty engines.
(HEAVY DUTY TEST CYCLE GVW 8,500 lbs to 14,000 lbs)

Hydrocarbons (HC)	.40 grams per megajoule
Carbon monoxide (CO)	5.35 grams per megajoule
Nitrogen Oxides (Nox)	2.23 grams per megajoule
Particulates	1.11 grams per megajoule

Maximum permitted emissions: Medium - heavy-duty engines
(GVW 14,000 lbs to 33,000 lbs)

Hydrocarbons (HC)	.70 grams per megajoule
Carbon monoxide (CO)	14.0 grams per megajoule
Nitrogen Oxides (Nox)	2.23 grams per megajoule
Particulates	1.5 grams per megajoule

Evaporative emissions have been prescribed for all gasoline engines.

Criterion for Acceptance

Each manufacturer proves that model of engine which he proposes to sell in Canada, when new (less than 100 hours in operation) emits at less than the prescribed maximum rate when run on the prescribed test cycle. Proof would be test data provided for trucks in a manner similar to what is now provided for cars; or a certificate from EPA in the U.S.A. that the engine meets the standards set by EPA.

Excluded from the Canadian regulations would be in-use enforcement by the following provisions:

a) useful life
b) deterioration factors
c) emissions averaging
d) allowable maintenance

10.2 Fuel Economy, Average Annual Distance Travelled, Vehicle Life Estimates for Trucks with GVW 8,500 lbs to 33,000 lbs.

Vehicle Category GVW	Fuel Economy (L/100 km)	Annual Distance (km)	Vehicle Life (years)	Annual Fuel Consumption Litres
8,500 to 14,000	20.6	17,700	10	3,646 L
15,000 to 33,000	38.9	48,300	9	18,789

Source: EPA (1985) and EMR (1985)

10.3 Forecast of Sales of Trucks with Gasoline Engines

TABLE 15

Year	Light GVW 8,500 lbs or more	Medium	Medium Heavy
1990	50,800	1,500	1,600
1991	50,000	1,500	1,500
1992	50,500	1,500	1,400
1993	50,000	1,500	1,300
1994	49,800	1,500	1,200
1995	49,000	1,500	1,000
1996	47,200	1,500	1,000
1997	42,600	1,500	1,100
1998	41,000	1,600	1,100
1999	41,000	1,700	1,100
2000	39,600	1,800	1,200

Source: Energy, Mines and Resources Canada, Trends in the Canadian Truck Market, P. 30, 36.

This forecast of sales of trucks having gasoline engines takes into account the observation in the U.S.A. that in the absence of these regulations, manufacturers of trucks are likely to classify a much larger portion of their light duty trucks into a gross vehicle weight exceeding 8,500 pounds in order to eliminate the additional cost of equipment to reduce emissions from trucks with a GVW less than 8,500 pounds.

10.4 Unit Cost of Equipment on Light Trucks With GVW 8,500 lbs to 14,000 lbs.

The manufacturer's shares and incremental prices are approximately:

Manufacturer	Share	Price	Share x Price
Ford 4.9 L	9%	$455	$40
Other	25%	Ø	Ø
GM	45%	$900	$405
Chrysler	21%	Ø	Ø
		Composite Price	$445.00

Source: Energy and Environmental Analysis, Inc., Arlington Virginia, Analysis of the Impact of Adopting U.S. Heavy Duty Truck Emission Regulations In Canada, 1985, P. 5-3

10.5 Unit Cost of Equipment on Medium and Medium-Heavy Trucks with GVW 14,000 to 33,000 lbs.

These trucks meet the present Canadian emission standards by using lean-burn technology, advanced spark timing and either one air pump into the exhaust manifold or no air pump. As a result the engine exhaust temperature is sufficiently low that engines can have cast iron exhaust manifolds and carbon steel exhaust pipes.

These gasoline engines would be constructed differently in order to meet either U.S. 1985 emission standards or the U.S. 1988 emission standards. In order to reduce NOx; spark timing would be retarded, and two air pumps, one for each bank of cylinders, would inject air into the exhaust manifold to burn the excess hydrocarbons and carbon monoxide in the engine's exhaust. The high temperatures created

by this combustion in the exhaust manifold, could cause a cast iron manifold to crack, or to oxydize prematurely. Engine manufacturers have solved this problem of durability by installing on these engines, stainless steel exhaust manifolds, and stainless steel exhaust pipes. The increase in cost to Canadians purchasing trucks with this additional equipment is estimated to be $920 Canadian per Vehicle.

Energy and Environmental Analysis, Inc., Analysis of the Impact of Adopting U.S. Heavy-Duty Truck Emission Regulations in Canada, December 1985, Page 5-25.

R237/4734R

TABLE 16

COST OF 1989 REGULATIONS FOR GASOLINE POWERED TRUCKS

(Millions of Dollars)

Year	Light Trucks			Medium Trucks			Medium Heavy Trucks			Annual Cost
	Equipment Cost	Fuel Consumed 10^6 Litres	Penalty Cost	Equipment Cost	Fuel Consumed 10^6 Litres	Penalty Cost	Equipment Cost	Fuel Consumed 10^6 Litres	Penalty Cost	
1990	22.6	185.2	.7	1.4	28.2	.5	1.5	30.1	.5	27.2
1991	22.3	182.3	1.4	1.4	28.2	1.0	1.4	28.2	1.0	28.5
1992	22.5	184.1	2.1	1.4	28.2	1.5	1.3	26.3	1.5	30.3
1993	22.3	182.3	2.8	1.4	28.2	2.0	-	24.4	2.0	31.7
1994	22.2	181.6	3.5	1.4	28.2	2.5	1.1	22.5	2.4	33.1
1995	21.8	178.7	4.1	1.4	28.2	3.0	.9	18.8	2.7	33.9
1996	21.0	172.1	4.7	1.4	28.2	3.5	.9	18.8	3.0	34.5
1997	19.0	155.3	5.2	1.4	28.2	4.0	1.0	20.7	3.4	34.0
1998	18.2	149.5	5.7	1.5	30.1	4.5	1.0	20.7	3.8	34.7
1999	18.2	149.5	6.2	1.6	31.9	4.4	1.0	20.7	3.7	35.1
2000	17.4	142.2	6.0	1.7	33.8	4.3	1.1	22.5	3.6	34.1
	227.5		42.4	16.0		31.2	12.4		27.6	357.1

11.0 COST TO CANADIANS OF THE IMPACT OF PROPOSED 1995 REGULATIONS ON SALES OF TRUCKS WITH GASOLINE ENGINES

One impact of proposed 1995 Regulations would be to change the sales mix of engines in trucks. Table 16 forecasts the sales of trucks assuming the implementation of 1995 regulations. Table 17 forecasts the cost of 1988 and 1999 Regulations. The incremental cost of the impact of the 1995 regulations is obtained by substracting the costs shown in Table 14 from the costs shown in Table 17. These incremental costs are shown in Table 18.

11.1 Forecast of Sales of Trucks with Gasoline Engines Assuming Adoption of 1995 Regulations

TABLE 17

Year	Light GVW 8,500 lbs or more	Medium	Medium Heavy
1990	53,140	2,400	2,400
1991	53,500	2,400	2,550
1992	54,060	2,600	2,450
1993	55,720	2,600	2,800
1994	54,580	2,800	2,950
1995	55,040	3,000	3,000
1996	55,700	3,000	3,150
1997	53,660	3,200	3,300
1998	54,620	3,200	3,300
1999	57,140	3,400	3,300
2000	57,700	3,600	3,600

Source: Energy, Mines and Resources Canada, Trends in the Canadian Truck Market, P. 30, 36.

This forecast of sales of trucks having gasoline engines takes into account the opinion expressed in paragraph 7.2 that the regulations proposed for 1995 to limit emissions from heavy duty trucks would discourage many customers from buying trucks with diesel engines. Instead, they would buy gasoline engines in their trucks in order to avoid the many difficulties posed by the regulations.

TABLE 18

COST OF 1988 AND 1995 REGULATIONS FOR GASOLINE POWERED TRUCKS

(Millions of Dollars)

Year	Light Trucks			Medium Trucks			Medium Heavy Trucks			Annual Cost
	Equipment Cost	Fuel Consumed 10^6 Litres	Penalty Cost	Equipment Cost	Fuel Consumed 10^6 Litres	Penalty Cost	Equipment Cost	Fuel Consumed 10^6 Litres	Penalty Cost	
1990	23.6	193.7	.7	2.2	45.1	.8	2.2	45.1	.8	30.3
1991	23.8	195.1	1.4	2.2	45.1	1.6	2.3	47.9	1.7	33.0
1992	24.1	197.1	2.1	2.4	48.9	2.5	2.3	47.9	2.6	36.0
1993	24.8	203.2	2.8	2.4	48.9	3.4	2.6	52.6	3.5	39.5
1994	24.3	199.0	3.5	2.6	52.6	4.3	2.7	55.4	4.5	41.9
1995	24.5	200.7	4.2	2.8	56.4	5.3	2.8	56.4	5.5	45.1
1996	24.8	203.1	4.9	2.8	56.4	6.3	2.9	59.2	6.6	48.3
1997	23.9	195.6	5.6	2.8	56.4	7.3	3.0	62.0	7.7	50.3
1998	24.3	199.1	6.4	2.9	60.1	8.4	3.0	62.0	8.8	53.8
1999	25.4	208.3	7.2	3.1	63.9	8.7	3.0	62.0	9.1	56.4
2000	25.7	210.4	7.3	3.3	67.6	9.1	3.3	67.6	9.4	58.1
	269.2		46.1	29.5		57.7	30.1		60.2	492.8

R237/4734R

TABLE 19

INCREMENTAL COST OF IMPACT OF 1995
REGULATIONS ON TRUCKS WITH GASOLINE ENGINES

Year	Annual Cost Table 17	Annual Cost Table 15	Incremental Cost
1990	30.3	27.2	3.1
1991	33.0	28.5	4.5
1992	36.0	30.3	5.7
1993	39.5	31.7	7.8
1994	41.9	33.1	8.8
1995	45.1	33.9	11.2
1996	48.3	34.5	13.8
1997	50.3	34.0	16.3
1998	53.8	34.7	19.2
1999	56.4	35.1	21.3
2000	58.1	34.1	21.3
	492.8	357.1	135.6

12.0 THE COST OF ALTERNATE FUELS IN BUSES

The implementation of the Canadian 1995 regulations described in section 7 of this report presents a special situation for urban buses because engines for urban buses have been developed using the following fuels:

1. Diesel fuel
2. Propane
3. Compressed natural gas or liquefied natural gas
4. Methanol

This section of the study forecasts the costs of using the above mentioned fuels to meet the proposed Canadian 1995 standards in urban buses. In this forecast the sales rate of 500 units annually is based on the average number of buses sold in Canada annually between 1978 and 1983. Table 19 indicates the cost per vehicle associated with meeting the proposed 1995 regulations in buses, using the four different fuels for which bus engines have been developed. The cost of using compressed natural gas as a bus fuel is similar to the cost of using propane.

Since the costs per vehicle are not very different, these alternate fuels are viable alternatives if no satisfactory particulate traps are developed for urban buses which have diesel engines.

TABLE 20

EXPECTED COST TO MEET 1995 REGULATIONS FOR
EACH NEW BUS PURCHASED

ITEM	DIESEL FUEL	PROPANE	LIQUIFIED NATURAL GAS	METHANOL
Kilometres Travelled Annually	60,000	60,000	60,000	60,000
Litres per Kilometer	.61*	.92	1.02	1.14
Litres Consumed Annually	36,600	55,284	61,020	66,840
Cost per Litre $(Excluding Sales Taxes)	.312	.213	.197	.215
Fuel Costs Per Year	$11,419	$11,775	$12,020	$14,371
Conversion Cost Including Pollution Control Equipment	$3,000	$2,900	$9,800	$1,800

* Includes 13% fuel penalty of 1995 Regulations.

Source: R.F. Webb Corporation Ltd. Padgett Process Services Ltd.
William G. Mathews Associates Ltd., Alternative Fuel Cost Study, March 1984, Prepared for Ministry of State for Science a· Technology.

13.0 PRESENT VALUE CALCULATIONS

In order to facilitate the comparison of the previously calculated costs with any benefits from the regulations, the present value in the year 1986 of the costs for Canadian 1989 regulations and Canadian 1995 regulations are presented in Table 20.

TABLE 21

EXPECTED PRESENT VALUE (1986) OF INCREMENTAL ALLOCATIVE COSTS OF CANADIAN 1989 AND CANADIAN 1995 REGULATIONS

(Millions Canadian 1985 Dollars)

Year	Cost 1989 Regulations Table 5 Plus Table 15		Cost 1995 Regulations Table 13 Plus Table 18	
	Actual	Present Value	Actual	Present Value
1990	33.8	23.0	39.3	26.7
1991	41.6	25.8	55.6	34.5
1992	50.6	28.3	72.2	40.4
1993	59.0	30.1	91.3	46.6
1994	67.7	31.1	110.7	50.9
1995	76.0	31.9	300.8	126.3
1996	84.3	32.0	346.2	131.6
1997	91.9	32.2	373.1	130.6
1998	95.7	27.8	385.9	111.9
1999	98.2	25.5	393.3	102.3
2000	99.4	23.9	404.5	97.1
	798.2	311.6	2572.9	898.9